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GRADES OF HAY AND THEIR FEEDING VALUE[1/]

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Modern concepts of efficient animal husbandry have brought about a realization among progressive farmers of the feeding economies possible through the use of high quality hay. Since hay probably varies more in quality and feeding value than any other harvested feed crop with the possible exception of silage, the assignment of a value to any specific hay lot, consistent with the true feeding value, is most difficult. However, the difficulty of the task in no way relieves us of the responsibility of making the best possible evaluation, particularly if the hay is to be sold.

Economic position of the hay crop

The value of the national hay crop harvested each year represents a major portion of the total feed crops harvested. It may be seen from Table 1 that hay, when compared to other major feed crops, occupies a position only slightly lower than wheat as regards estimated total crop value. This relatively important economic position is often overlooked because only a small portion is actually sold on the open market. Although a major portion of the total hay remains on the farm where it was grown, as compared to grain crops because of its bulk and its unsuitability as a human food, nevertheless a knowledge of the true feeding value of that major crop would be of tremendous benefit to the men producing or feeding the hay.

Hay as a source of nutrients

High quality roughage provides all of the nutritional needs of an adult ruminant for maintenance and some production. Since roughage is usually our cheapest source of feed nutrients, high quality hay has an important place in efficient animal production. The exact chemical composition of hay is complex and not at all well understood. Those chemical constituents that appear to be most closely correlated with differences in the feeding value of different hays may be classified as energy (often expressed as TDN), protein, minerals and vitamins. The

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1/ Paper presented at the annual convention of the National Hay Association, Inc., St. Louis, Mo., August 29, 1955.

Table 1.-Production and value of U. S. feed crops 1952[1/]

	Production[3/]			Estimated value $1,000[2/]		
	Total	Kept on farms	Sold from farms	Total	Kept on farms	Sold
Hay	104,424	90,393	14,031	2,589,715	2,241,746	347,969
Corn	3,306,735	2,342,350	964,385	4,993,170	3,536,949	1,456,221
Wheat	1,291,447	137,040	1,154,407	2,699,124	286,414	2,412,711
Oats	1,268,280	981,573	286,707	1,001,941	775,443	226,499
Barley	227,008	88,894	138,114	308,731	120,896	187,835

1/ Adapted from Agricultural Statistics 1953, U.S.D.A.
2/ Prices received by farmers for baled hay 24.80/ton; corn 1.51/bu.; wheat 2.09/bu.; oats 0.29/bu.; barley 1.35/bu.
3/ Hay, 1,000 ton units; grain, 1,000 bu. units.

factor most often limiting the extent to which hay can be utilized in the ration of a high producing animal is not a single chemical constituent, but the complex factor of palatability or the rate at which the hay will be consumed by an animal. Theoretically, if an animal could, and would, consume sufficiently large amounts of a hay low in nutrient content, the result would be as satisfactory as with smaller amounts of a hay high in nutrient content.

High quality hays enjoy a dual advantage in that they not only contain a higher concentration of necessary nutrients but they are also more palatable and will be consumed in larger amounts than hay of lower feeding value. It may be seen from Table 2 that the amounts of some hays necessary for meeting nutritional requirements may exceed the animal's hay consuming capacity. In other words, if the farmer is to make the best use of his cheapest source of nutrients he must provide hay that is not only rich in nutrients but also palatable. Failure to do so will result in a greater supplementation with concentrates or a lower level of production.

The effect of weather on hay quality and cost

The stage of maturity at cutting and exposure to weather during the curing period account, to a large extent, for differentials in the final feeding value of different hays produced from fields containing the same plant species. The stage of maturity at the time of cutting can be

Table 2.-Hay needed to meet the daily TDN, protein and carotene requirements of 1,000 lb. cow producing 20 lbs. FCM 1/

Hay	Pounds of hay needed to meet daily requirement		
	TDN	Protein	Carotene
Timothy Hay before bloom No. 1 in color	25	30	14
Timothy Hay full bloom No. 2 in color	30	49	28
Timothy Hay late seed No. 3 in color	34	78	48

1/ Adapted from Feeds and Feeding, F. B. Morrison, 21st. edition

controlled, to a great extent, by proper management. Exposure to weather during the curing period is much less easily controlled. A highly nutritious and palatable hay crop is often changed, within a few days to a dark, stemmy, dusty material, of very low feeding value.

Figure 1 shows the effect on nutrient losses of extended weather exposure caused by unfavorable drying conditions. The observations were made on 19 lots of alfalfa harvested at Beltsville during a five year period. The data on labor and machinery requirements for some of the same harvests are summarized in Table 3. It is apparent from these data that the crops harvested after long exposure to weather experienced heavier field losses, were of lower nutritive content and were more costly than those crops having relatively short periods of weather exposure.

While it is recognized that weather conditions are uncontrollable, and sometimes unpredictable, it does appear that mechanical aids such as crushers and driers which reduce the extent of weather exposure are often an economy rather than added expense.

The official hay grading system

The wide variability in the nutrient content and the palatability of hays has been pointed out in the preceding sections. The combined effect of nutrient content and palatability determine the quality or feeding value of hay. Although this variability has been recognized for a great many years, the work leading to our present system of standards and grading was not started until 1919; official inspection and grading of hay on the basis of published standards was started in 1923. This service is now performed by the Agricultural Marketing Service.

In establishing these classification and grading standards consideration was given to specie, color, leaf content, foreign material, odor, dustiness and moldiness. These criteria were utilized because they were known to be

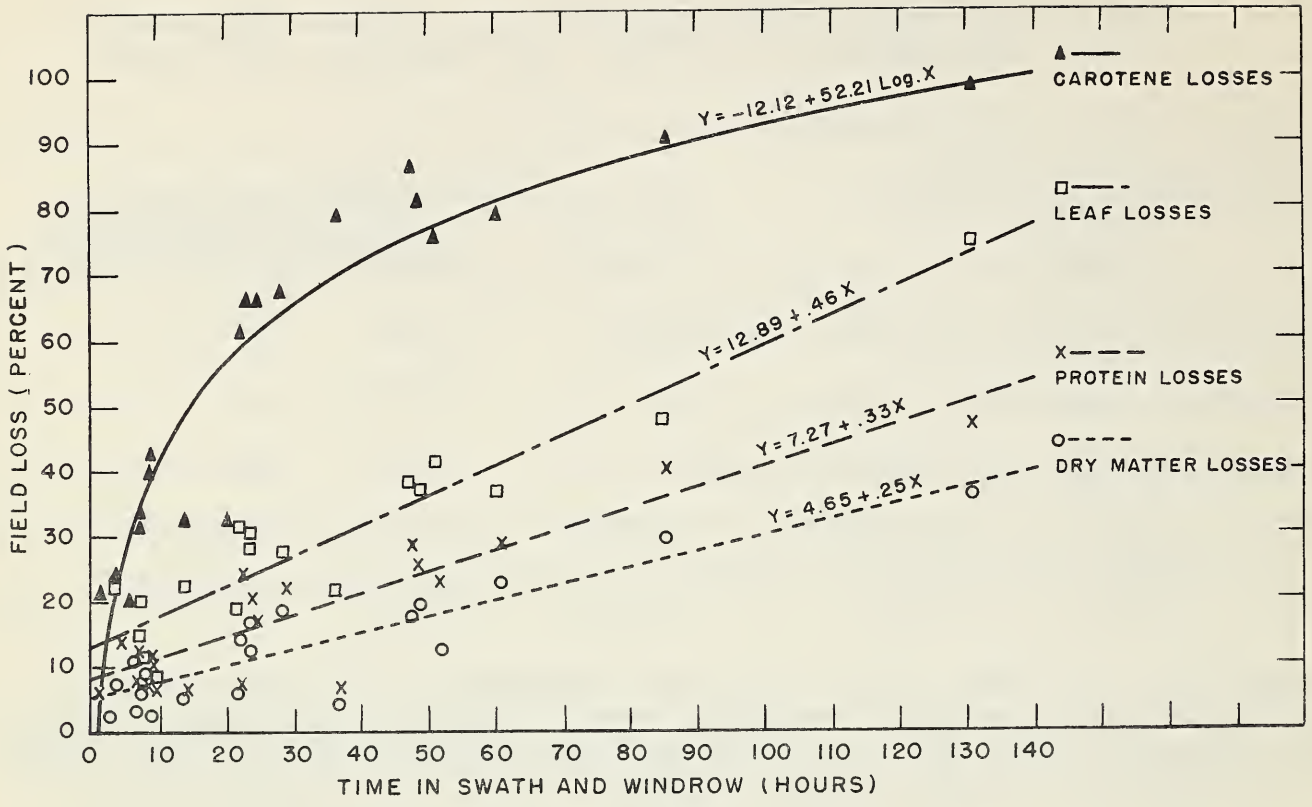

Figure 1.-Relationship between time in swath and windrow and losses of nutrients in the field.

Table 3.-Labor, power, and machinery requirements (hours per ton of dry-matter preserved) for harvesting and storing forage, 1945-47 1/

Item	Wilted silage	Barn-cured hay 2/	Field-cured hay	Rain-damaged field-cured hay
Labor	4.87	4.59	4.33	6.30
Tractor	1.35	1.32	1.57	3.38
Mower	.47	.47	.53	.65
Rake	.35	.44	.84	2.46
Loader	.48	.41	.44	.66
Truck	1.66	1.30	1.99	1.84
Silo filler	.54	--	--	--
Hay hoist	--	.41	.30	.28

1/ All forage was loaded onto trucks with a heavy-duty hay loader from the windrow.
2/ Fan operation, electricity, and heat required in addition.

related to nutrient content and palatability and because they were factors that could be determined in the field without special equipment. The establishment of allowable limits of such factors as specie and color for any specific class or grade were necessarily somewhat arbitrary, but the system has, nevertheless, promoted uniform terminology in the trade and made possible the sale and purchase of hay without personal inspection.

The question of just how much difference in feeding value there may be, if any, between hays graded as No. 1 and No. 2 of the same class or between hays of the same grade, classified as light or heavy grass mixed has often been raised. These are legitimate questions since little experimental data is available on the comparative feeding value of officially graded hays. An attempt to obtain such data is being carried out jointly by the Agricultural Marketing Service and the Dairy Husbandry Research Branch. A partial summary of these experiments is presented in the following sections.

The relationship of grade to feeding value for milk production

The effect of varying amounts of foreign material in Korean lespedeza hay was studied in two feeding trials over a 2 year period. In this experiment the grades of lespedeza hay used were selected to most closely represent the greater part of the lespedeza hay produced. Each year a test was conducted comparing the feeding value for milking cows of U. S. No. 3 Leafy Green Lespedeza Hay with U. S. Sample Grade Extra Leafy Lespedeza Hay.

The average grade of the four hays used, based on careful sampling during the feeding trial is presented in Table 4. It should be pointed out that leafiness determinations are based only on the lespedeza portion of the total sample. These hays contained a high enough leaf content in the lespedeza and high enough color to qualify as No. 1 or No. 1 Extra Leafy U. S. grade, but the large amounts of foreign material, mainly grain stubble and weeds, were responsible for the lower grades.

Feed consumption and milk production data are presented in Table 5. The important fact revealed in these experiments is that the U. S. Sample grade hays, apparently because of their higher content of foreign material, were less palatable than the U. S. grade 3 hays and therefore considerably more of the Sample grade hays had to be fed to obtain the same results that were obtained from feeding U. S. 3 grade hay. Considering both experiments, 6 lbs. more U. S. Sample grade hay than U. S. 3 grade hay were fed per day to produce essentially the same result. On the basis of the amount of hay fed, it took 33.6 lbs. of U. S. Sample grade hay per day to produce 19.8 lbs. of milk, or 170 lbs. of hay per 100 lbs. of milk produced. For the U. S. 3 grade hay, it required 27.6 lbs. of hay to produce 20.0 lbs. of milk, or 138 lbs. of hay per 100 lbs. of milk. Using this comparison, it would require about 23% more U. S. Sample grade hay to produce the same amount of milk. From the results of these studies, it appears that this is the difference that may be ascribed to the two U. S. grades of lespedeza hay used under practical conditions. This would mean that about 5 tons of U. S. Sample grade lespedeza hay would be needed to equal 4 tons of U. S. 3 grade lespedeza hay.

Table 4.-Official U. S. grade of hays used in lespedeza hay feeding experiments

Expt. (No.)	Lot (No.)	Leaf content of lespedeza (%)	Foreign material in hay (%)	Color in hay	Official grades
1	1	53.1	17.6	Green to greenish-brown	U. S. No. 3 Leafy Green
1	2	57.7	31.9	Green to greenish-brown	U. S. Sample Grade, Green, Extra Leafy
2	3	53.4	19.0	Green to greenish-brown	U. S. No. 3 Leafy Green
2	4	58.3	34.8	Greenish-brown to brown	U. S. Sample Grade, Extra Leafy
Av. 1 and 3		53.2	18.3	Green to greenish-brown	U. S. No. 3 Leafy Green
Av. 2 and 4		58.0	33.3	Green to greenish-brown	U. S. Sample Grade, Green, Extra Leafy

Table 5.-Feed consumption and production of milking cows fed the experimental lespedeza hays (per cow per day basis) 1/

Lot No.	No. of cows	Feed consumption: Hay fed	Hay refused	Grain fed	Dry matter consumption: From hay	From grain	Total	Liveweight: Total	Daily change	Milk prod.	Dry matter consumed per lb. of milk produced
		(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
					Experiment 1						
1	8	26.5	4.9	4.7	19.2	4.4	23.6	820	-.30	18.2	1.30
2	8	32.6	10.2	4.7	20.3	4.3	24.6	820	-.28	19.0	1.30
					Experiment 2						
3	8	28.6	4.0	5.6	22.7	5.0	27.7	873	-.07	21.7	1.28
4	8	34.6	8.9	5.5	23.7	4.8	28.5	862	+.04	20.7	1.38
Av. U. S. No. 3 Leafy Green Lespedeza Hay (Expt. 1, lot 1 and Expt. 2, lot 3)											
1 & 3	8	27.6	4.4	5.2	21.0	4.7	25.6	846	-.18	20.0	1.29
Av. U. S. Sample Grade Green Extra Leafy Lespedeza Hay (Expt. 1, lot 2 and Expt. 2, lot 4)											
2 & 4	8	33.6	9.6	5.1	22.0	4.6	26.6	841	-.12	19.8	1.34

1/ In expt. 2, cows No. 168 and 345, both in lot 2, had attacks of mastitis at the beginning of the preliminary interval of period 1. Cow No. 272 of lot 1 aborted on the 12th day before the end of the experiment. Since her performance apparently was normal up to that time, her feed consumption, body weight and milk production for the last 12 days were estimated on the basis of her previous performance.

In the feeding trial with lespedeza, reported above, the deficiency of the lower grade hay was compensated for by allowing the cows to pick out the more palatable portions. However, this is not always possible or practical. U. S. No. 1 Alfalfa Hay and U. S. No. 3 Alfalfa Hay were compared in a feeding trial at Huntley, Montana, in which the cows were fed in the same way except for differences in the grade of hay. It may be seen from Table 6 that the cows did not consume as much of the No. 3 hay and that the lower nutrient intake was reflected in lower milk production. Additional grain supplements could have resulted in equal production from the group on No. 3 hay. A four pound grain supplement might have replaced the eight pound differential in hay intake. At $70.00 per ton for supplements this would have been an added expense of $.14 per day per cow or $1,004 per year for a twenty cow herd. Is there an easier way for a farmer to save $1,000 than by producing and feeding high quality hay, particularly since our figures show that higher quality hay is usually less expensive to produce?

Table 6.-Effect of hay quality on milk yields

Grade of hay fed	Leafiness	Protein	Fiber	Dry matter consumed per day	Daily milk yields
	%	%	%	(pounds)	(pounds)
U. S. No. 1 Alfalfa	50	18.6	21.2	36.2	42.6
U. S. No. 3 Alfalfa	29	14.6	32.4	28.2	36.7

The feeding value of different grades of alfalfa hay for growing dairy heifers

A study of the feeding value of different official grades of alfalfa hay has been under way at Beltsville since 1949. The feeding value is measured by feeding a single lot of hay to dairy heifers as the sole ration, except for mineral supplements, for a period of 120-150 days. These heifers range from 9-16 months in age at the start of the feeding trials. Hay is fed to the extent of appetite with a 10% weighback allowed. Live weight gains are considered as the principle criterion in estimating feeding value.

During the experiments of 1949-50 and 1950-51 an attempt was made to study the differential in feeding value of U. S. No. 1 and U. S. No. 3 Alfalfa Hay. It is apparent from the data on the characteristics of the hays used (Table 7) that the hays obtained did not in every case meet the standards for the grade desired. While this is unfortunate it was felt that the hays used represented, for practical purposes, the desired differentials in grade. One large lot for each grade was used in the 1949-50 experiment while three lots for each grade were used in 1950-51 thus obtaining a better sampling of each market grade.

Table 7.-Official U. S. grades of hays used in heifer feeding trials 1949-51

Lot	Alfalfa	Grass	Clover	Foreign material	Leafiness of alfalfa	Color		U. S. grade
	(%)	(%)	(%)	(%)	(%)	(Hue)[1]	(%)	
				Experiment I 1949-50				
A	91.7	8.0	---	4.1	37.4	-----	60	U. S. no. 2 Green Alfalfa Light Grass Mixed Hay
B	94.0	5.5	---	5.1	21.0	-----	41	U. S. no. 3 Alfalfa Hay
				Experiment II 1950-51				
A	96.0	2.7	1.3	4.7	51.4	7.20y	65	U. S. no. 1 Extra Leafy Alfalfa Hay
B	90.5	9.5	Trace	1.6	42.6	6.20y	60	U. S. no. 1 Alfalfa Light Grass Mixed Hay
C	96.9	3.0	0.1	6.0	48.7	5.55y	54	U. S. no. 2 Leafy Alfalfa Hay
Av.	94.4	5.1	0.5	4.1	45.6	6.32y	60	U. S. no. 1 Alfalfa Hay
D	74.6	24.8	0.6	9.1	20.8	4.80y	48	U. S. no. 2 Alfalfa Heavy Grass Mixed Hay
E	90.4	9.6	Trace	3.9	10.8	3.47y	34	U. S. no. 3 Alfalfa Light Grass Mixed Hay
F	96.5	3.3	0.2	14.6	24.4	2.79y	24	U. S. no. 3 Alfalfa Hay
Av.	87.2	12.6	0.3	9.2	18.7	3.69y	36	U. S. no. 3 Alfalfa Light Grass Mixed Hay

1/ Hue designation on the basis of the Munsell color system.

The results of the first experiment (1949-50) showed that the U. S. No. 2 Green Alfalfa Light Grass Mixed Hay had a higher feeding value than the U. S. No. 3 Alfalfa Hay (Table 8). It should be pointed out, however that the No. 2 hay would have been graded No. 1 had its leaf content been slightly higher.

Table 8.- Results of 1949-51 heifer feeding trial, gain in body weight and hay consumption per heifer

Total gain	Average daily gain	Alfalfa hay/day			Dry matter/day			Dry matter consumed/ lb. gain
		Fed	Refused	Consumed	Fed	Refused	Consumed	
(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
Experiment I 1949-50								
Group A-U. S. No. 2 Green Alfalfa Light Grass Mixed Hay								
262	1.75	22.0	2.1	19.9	19.7	1.8	17.9	10.20
Group B-U. S. No. 3 Alfalfa Hay								
212	1.41	20.1	1.9	18.2	18.0	1.7	16.3	11.67
Experiment II 1950-51								
Group A-U. S. No. 1 Extra Leafy Alfalfa Hay								
178	1.48	24.1	1.9	22.1	19.9	1.6	18.3	13.13
Group B-U. S. No. 1 Alfalfa Light Grass Mixed Hay								
181	1.50	19.6	1.9	18.9	16.7	1.6	15.2	11.00
Group C-U. S. No. 2 Leafy Alfalfa Hay								
187	1.56	21.9	1.8	20.1	17.7	1.6	16.1	10.48
Groups A, B, and C-Average U. S. No. 1 Alfalfa Hay								
Av.	1.51	21.9	1.9	20.3	18.1	1.6	16.5	11.53
Group D-U. S. No. 2 Alfalfa Heavy Grass Mixed Hay								
122	1.02	20.6	1.9	18.7	16.5	1.6	14.9	15.69
Group E-U. S. No. 3 Alfalfa Light Grass Mixed Hay								
147	1.23	18.9	1.8	17.1	15.1	1.5	13.6	11.89
Group F-U. S. No. 3 Alfalfa Hay								
146	1.22	18.9	1.7	17.2	14.9	1.4	13.5	11.14
Groups D, E, and F-Average No. 3 Alfalfa Light Grass Mixed Hay								
Av.	1.15	19.5	1.8	17.7	15.5	1.5	14.0	12.91

The differences in leaf content (16%) and color (19%) apparently were sufficient to affect palatability, so that the heifers on No. 2 hay consumed 1.6 pounds more dry matter per day than the heifers on the No. 3 hay. There also were differences between the No. 2 and 3 hays in chemical composition.

Under practical conditions, in order to obtain the most economical gains, the farmer would desire to feed the hay which produced the most rapid gain, provided the difference in cost was not too great. The heifers on No. 2 hay made considerably greater average daily gains of body weight than those on No. 3 hay and consumed 12.5% less dry matter per pound of gain.

In the second experiment (1950-51), about the same results were obtained as in the previous year. When the six lots of hay were arranged in order according to leaf content, along with data on protein, crude fiber, dry matter consumption and daily gain, as shown in Table 9, there was a close relationship between these factors. In general, the greater the leaf content, the greater the protein content, the less the fiber content and the greater the consumption and average daily gains. It is surprising that lot E with the lowest leaf content and the highest fiber content did not produce the poorest gain. This may have been due to animal variation, but it is more likely that other factors were operating which are not measured by present chemical and physical means. The variation in the gains on the three different lots of No. 3 hay may also be due to the variation in the percentage of grass or foreign material in the different lots or the difference in stage of maturity which was not determined. The lot which contained the largest percentage of grass, lot D, with 25% of grass, gave the lowest gains. Lot F, with the highest percentage of foreign material, also gave somewhat lower average daily gains than lot E, although this difference is not significant. The effect of stage of maturity, not directly considered in the grading standards may also have been a factor.

When the three lots of hay that were fed to each group of heifers are averaged together, it required 10.7% less dry matter from the No. 1 hay to produce 1 pound of gain than from the No. 3 hay. Theoretically, supplementation with about 1.3 pounds of concentrate feed could have compensated for the 2.5 pounds difference in hay dry matter consumption between the No. 1 and No. 3 hays. This would have cost about 5 cents per day ($70 per ton price for concentrates) or about $1.50 per month per heifer.

The effect on feeding value of including considerable timothy in alfalfa hay

This experiment followed the same general plan as the preceding one. An attempt was made to obtain three lots of No. 1 Alfalfa (lots A, B and C) and three lots of No. 1 Alfalfa Heavy Timothy Mixed Hay (lots D, E and F). The final grade assigned on the basis of subsequent sampling appears in Table 10. The differences in composition accounting for the discrepancy between desired and final grade are very small in some cases and considerable in others.

A summary of the feeding trial data, Table 11, shows that on the average the No. 1 Alfalfa (lots A, B and C) was considerably more palatable and of a higher feeding value than the No. 2 Alfalfa Heavy Timothy Mixed (lots D, E and F). The results from lots B and E make a rather outstanding example of wide differences in feeding value although the only difference in designation is the item "Heavy Timothy Mixed".

Table 9.-Relationship between leaf, protein and crude fiber contents, consumption of dry matter and gain in body weight, 1949-51 heifer feeding trials

Lot	Leafiness of alfalfa (%)	Protein (%)	Crude fiber (%)	Dry matter consumed/day (lb.)	Av. daily gain (lb.)
			Experiment I 1949-50		
A	37.4	18.9	30.3	17.9	1.75
B	21.0	16.8	32.3	16.3	1.41
			Experiment II 1950-51		
A	51.4	22.5	27.0	18.3	1.479
C	48.7	19.5	26.2	16.1	1.558
B	42.6	18.9	29.4	15.2	1.502
F	24.4	16.4	37.1	13.5	1.217
D	20.8	13.5	37.2	14.9	1.015
E	10.8	14.4	42.2	13.6	1.227

Table 10.-Characteristics of grades of hay used in 1952-53 heifer feeding trials

Lot	Alfalfa (%)	Timothy (%)	Grass (%)	Clover (%)	Foreign material (%)	Leafiness of alfalfa (%)	Color (Hue) 1/	Color (% green)	Grade
A	92.4	0.0	7.6	Trace	1.8	50.5	7.13y	65	U.S. No. 1 Extra Leafy Alfalfa Light Grass Mixed Hay
B	97.6	0.0	2.4	Trace	3.4	32.2	6.16y	58	U. S. No. 2 Alfalfa Hay
C	96.3	0.0	3.7	Trace	1.3	51.1	7.58y	67	U.S. No. 1 Extra Leafy Alfalfa Hay
Av. A, B, C	95.4		4.6	Trace	2.2	44.6	6.96y	63	U.S. No. 1 Alfalfa Hay
D	54.4	45.3	0.0	0.3	1.2	27.1	4.78y	48	U.S. No. 2 Alfalfa Heavy Timothy Mixed Hay
E	35.7	62.7	1.3	0.3	2.9	35.2	5.20y	51	U.S. No. 2 Alfalfa Heavy Timothy Mixed Hay
F	75.6	24.4	0.0	Trace	1.6	28.5	5.14y	50	U.S. No. 2 Alfalfa Light Timothy Mixed Hay
Av. D, E, F	55.2	44.2	0.4	0.2	1.9	30.3	5.04y	50	U.S. No. 2 Alfalfa Heavy Timothy Mixed Hay

1/ Hue designation on the basis of the Munsell color system

Table 11.-Results of 1952-53 heifer feeding trial - hay consumption and gain in body weight per heifer

Hay/day			Dry matter/day			Dry matter consumed per pound gain	Total gain	Average daily gain
Fed (lb.)	Refused (lb.)	Consumed (lb.)	Fed (lb.)	Refused (lb.)	Consumed (lb.)	(lb.)	(lb.)	(lb.)
			Group A fed hay Lot A					
24.3	2.2	22.1	21.0	1.8	19.2	9.60	240	2.00
			Group B fed hay Lot B					
22.4	2.1	20.3	19.8	1.8	18.0	12.77	169	1.41
			Group C fed hay Lot C					
23.3	2.3	21.0	20.9	1.9	19.0	10.61	215	1.79
			Groups A, B, and C - Av. U. S. No. 1 Alfalfa Hay					
23.3	2.2	21.1	20.6	1.8	18.7	10.81	208	1.73
			Group D fed hay Lot D					
18.7	2.1	16.6	16.6	1.8	14.8	18.05	98	0.82
			Group E fed hay Lot E					
19.0	2.1	16.9	16.9	1.8	15.1	20.68	88	0.73
			Group F fed hay Lot F					
19.4	2.1	17.3	17.1	1.8	15.3	12.97	141	1.18
			Groups D, E, and F - Av. U. S. No. 2 Alfalfa Heavy Timothy Mixed Hay					
19.0	2.1	16.9	16.9	1.8	15.1	16.59	109	0.91

The correlation between certain factors and growth rate becomes apparent if the hays are arranged in the order of the growth they produced. This has been done in Table 11. It is noteworthy that, with few exceptions, the order of decreasing daily gains is also the order of decreasing leaf and protein content and palatability as measured by dry matter consumption. It is also the same order as increasing crude fiber and timothy content. The position of Lot E at the bottom of the list in spite of the relatively high leafiness of the alfalfa does not appear inconsistent when it is considered that alfalfa accounted for only 35.7% of the total forage present.

One might judge that the quality of timothy included in these mixed hays would have an important bearing on the total growth-producing ability of the hay since it accounted for up to 62.7% of the total forage (69% maximum allowable). However, under the present standards, color is the only quality factor of the timothy portion that is considered directly in determining the numerical grade designation of the hay.

It is of interest that the individual hay lot producing the most rapid gains (Lot A) was one containing sufficient grass to warrant the term "light Grass Mixed" yet the amount of grass was not sufficient to enable the demonstration of lower productive value under these conditions. This suggested the possibility that the maximum grass allowed by the present standards in the class Alfalfa Hay may be too restrictive.

The effect on feeding value of including small amounts to timothy in alfalfa hay

Since previous work had shown that the inclusion of timothy in alfalfa in the amounts allowed in the class Alfalfa Heavy Timothy Mixed Hay resulted in a significantly reduced feeding value, it was decided to measure the effect of including timothy in the amounts allowable in the class Alfalfa Light Timothy Mixed Hay.

Three lots of hay graded U. S. No. 1 Alfalfa Hay and three lots graded U. S. No. 1 Alfalfa Light Timothy Mixed Hay were purchased. The final grades of these hays were determined by analysis of samples taken during the feeding trial. On this basis, three lots had an average grade of U. S. No. 1 Alfalfa Hay and three lots had an average grade of U. S. No. 2 Alfalfa Light Timothy Mixed Hay. The latter group was slightly below the requirements for the No. 1 grade with respect to leafiness (range 34-39%, required 40%) and color (range 52-60%, required 60%). The timothy contents of these three lots were typical of the class Alfalfa Light Timothy Mixed (range 10-12%, allowable limits 6-30%).

When fed to growing dairy heifers during a 150-day feeding trial there were no significant differences in the feeding value of the six lots as measured by growth rate or consumption rate. All six lots produced normal gains. The average chemical composition of groups A, B and C, and D, E and F was also very similar.

The results suggest that considerably more timothy could be allowed in the class Alfalfa Hay than is presently allowed, thus simplifying the grading standards.

The most recent phase of this study has been a comparison of U. S. No. 2 Alfalfa with U. S. No. 2 Alfalfa Light Timothy Mixed Hay, using three purchased lots of each grade. The data from this experiment have not yet been completely summarized, but a preliminary analysis indicates that inclusion of 13% or more of timothy resulted in a lowered growth rate except in the case of one hay lot which approached a No. 1 grade as regards leafiness and color.

Discussion

The experimental information now available is only a start on what is needed if we are to be able to accurately correlate the true feeding value of hays with the present system of grading. Nevertheless, it is important to recognize and try to utilize the information we have gained so far.

The first big stride forward was the establishment of the system of classification and grading that we now have. Even though the system was organized without the benefit of complete information on relative feeding value, the provision of uniform terminology is of tremendous value. Farmers, extension workers, hay buyers and hay sellers all refer to the same specific kind of hay when, for instance, the term U. S. No. 1 Timothy Light Clover Mixed Hay is used.

The experimental work thus far completed has shown rather consistently that palatability is associated as much if not more so than percent nutrient content with differentials in total feeding value. This was demonstrated in the experiment with lespedeza hay when the effect on palatability varied so much with additional foreign material that 23% more of the Sample Grade hay had to be fed to achieve essentially the same results. The experiment with alfalfa hays of differing official grade also showed a very close relationship between rate of consumption and feeding value.

While in general, data on feeding value has justified the present grading system, it has also brought to our attention some weaknesses in the system. The one most frequently encountered is the problem of having to down-grade a hay because it fails by a small margin to meet just one requirement. An example of this problem is provided by Lot A of the 1949-50 Beltsville experiment (Table 7). This lot was down-graded from No. 1 to No. 2 because of a slight deficiency in percent of leaves (37.4% present 40% required). Yet this hay had one of the highest feeding values of any of the lots used. Some revision of the system to allow a slight deficiency in one characteristic to be compensated for by excellence in another characteristic should provide for a better expression of feeding value. This might be accomplished by a point system of grading with the total score determining which grade should be assigned.

The present 5% limit on grasses allowed in the class Alfalfa Hay, appears to be too restrictive. To broaden the limits of this class would necessitate some rearrangement of the present light and heavy grass and timothy mixed classes. Present knowledge indicates that probably 10% grass could be allowed in the class alfalfa with no demonstratable change in feeding value.

The adoption of additional criteria as a basis of grading would be advantageous. Under the present official standards no distinction can be made for hays of varying moisture content if below the 35% moisture level. However, on a strictly mathematical basis, hay which at a 20% moisture level is worth $35 per ton should be worth 12.5% more or about $39 per ton at a 10% moisture level. There are presently available directly reading moisture meters with an accuracy of about two percentage units at the levels usually found in hay. The characteristic of brittleness or harshness in some experimental hays has been associated with reduced palatability. Such hays cannot presently be down-graded on this basis yet they are often marked by lowered palatability. As yet no accurate method for measuring brittleness in hay has been devised that would be suitable for field inspections.

Direct evaluation of stage of maturity and consideration of this factor in grading would also be an improvement in the present grading standards.

Summary and Conclusions

The results from limited experimental work dealing with the relationships between official grades of hay and the feeding value of hay has been presented. These results appear to support the following conclusions.

1. The feeding value of lespedeza hay, containing large amounts of foreign material, is directly related to the percentage of actual lespedeza in the total hay since a large portion of the foreign material will be refused by dairy cows.

2. In general the higher the official grade of alfalfa the higher will be the feeding value for milking dairy cows and for producing weight gains in dairy heifers. However, some overlapping of the grades does occur.

3. Alfalfa hays including more than thirty percent of timothy may be expected to have significantly lower feeding value than pure alfalfa hay, but the inclusion of up to ten percent of timothy would probably have no significant effect.

4. The present standards for official grading could be improved by making provisions for recognition of the factors brittleness, moisture content and maturity and for recognition of hays that fail by a small margin to meet one requirement of a particular grade but are well within or above the grade as regards all other requirements.